

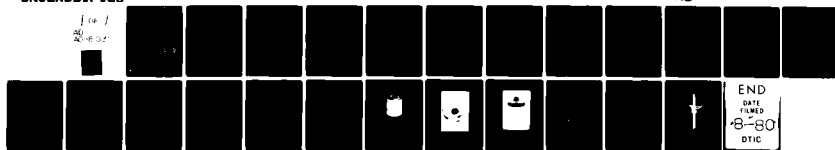
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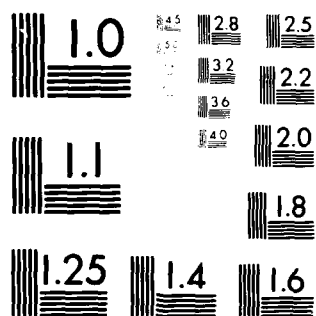
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MARGINAL SEALING QUALITY OF IRM AND CAVIT
AS ASSESSED BY MICROBIAL PENETRATION

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ABSTRACT

The ability of Proteus vulgaris to penetrate the seal provided by IRM and Cavit was investigated by using an in vitro model system consisting of extracted molar teeth embedded in acrylic. All temporaries were allowed to set for 24 hours next to a cotton pellet containing CMCP or saline. IRM which had set next to CMCP provided a significantly better seal after 3 weeks than IRM which had set next to saline, or Cavit which had set next to CMCP. Cavit placed next to saline was the least effective seal.

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Since endodontic therapy often requires multiple treatment appointments, a temporary filling material is required to seal the access preparation between visits to prevent contamination of the root canal with fluids, organic material, and bacteria from the oral cavity. Bacterial contamination of the root canal has been associated with endodontic failure by leading to a breakdown of the associated periodontal supporting structures.¹

Two of the most frequently used temporary materials are a polymer-reinforced zinc oxide-eugenol intermediate restorative material (IRM) and Cavit, a premixed noneugenol paste containing zinc oxide, calcium sulfate, zinc sulfate, glycol acetate, polyvinyl acetate, polyvinyl chloride acetate, tri-ethanolamine, and red pigment.² Form 1473

In posterior teeth, the temporary restorative material must be particularly strong to resist occlusal forces as well as to provide an adequate seal. IRM has been recommended rather than unmodified zinc oxide and eugenol to take advantage of the reported higher compressive strength and time saving characteristics.³

When the effects of temperature cycling on temporary restoratives have been assayed by dye penetration studies, Cavit maintained a leak proof seal; whereas zinc oxide-eugenol cement, zinc phosphate cement, and gutta-percha all allowed leakage.⁴ The superior seal obtained with Cavit during thermocycling was also observed by Parris and others⁵ using a bacteriologic assay system to check for microbial penetration.

An in vivo study⁶ evaluating seals obtained by temporary filling materials in endodontically treated anterior teeth using Cavit, Cavitron,

gutta-percha, three different zinc phosphate cements, and an unmodified zinc oxide-eugenol cement showed that Cavit and Cavitron provided the best seals. In this study, seepage was determined bacteriologically by culturing cotton pellets sealed into the access cavity.

Marosky and associates⁷ studied temporary sealing materials by using calcium chloride ^{45}Ca as a radioactive tracer to produce autoradiographs. They found IRM allowed significantly more leakage of ^{45}Ca than Cavit, zinc oxide-eugenol cement, or zinc phosphate cement. In contrast, Bramante and others⁸ using ^{131}I found IRM making a better seal than Cavit.

Many variables such as molecular size, pH, polarity, and capillary action may influence microleakage by radioactive labelled elements or dyes. Radioisotope leakage does not really indicate how microorganisms will penetrate the temporary seal. Penetration by microorganisms rather than by dyes or radioactive elements seems to be a more biologically significant approach.

Olmstead, Butler, and Gregory⁹ observed that IRM was softened more than Cavit or zinc phosphate cement when the set material was placed next to camphorated monochlorophenol (CMCP), formocresol or meta-cresylacetate. How the surface softening related to overall strength or its effect on the sealing ability of the temporary material was not evaluated. Keller and others¹⁰ studied the sealing quality of IRM and Cavit setting next to a medicated cotton pellet as assessed by bacterial penetration. Although Cavit models demonstrated equal or worse leakage than IRM models over a two-week period, the number of Cavit models were

too few to be significant. Their results seemed to confirm two other recent articles which question the sealing ability of Cavit.^{11,12}

The purpose of this study is to evaluate the sealing quality of IRM and Cavit as assessed by bacterial penetration (Proteus vulgaris) after the materials have set while in contact with CMCP.

METHODS AND MATERIALS

A modification of the model system described by Keller and others¹⁰ was used. The crowns of 86 noncarious, nonrestored, extracted human molar teeth were horizontally sectioned at mid pulp chamber level. Only the occlusal crown portions were retained. The entire enamel surface of each crown was etched for 2 minutes with a 50% phosphoric acid solution, washed under running tap water and dried to enhance an acrylic attachment. The crown was stabilized on the apex of a glass cone utilizing modeling compound. A plastic cylinder was placed over the tooth and glass cone so that its height was at the level of the crown's occlusal surface. Acrylic resin was poured into the space created to the height of the plastic cylinder (Fig 1). After the initial set, the plastic cylinder with the crown and surrounding acrylic was separated from the glass cone (Fig 2). This provided a model system with a funnel-shaped well into which sterile trypticase soy broth (TSB) culture medium could be placed in contact with the exposed cut pulpal surface of the crown. The external tooth enamel-acrylic margins and the plastic cylinder-acrylic margins were sealed with an enamel paint.[‡] This further insured an effective barrier to the microorganisms.

A plastic cap which snapped over the plastic cylinder was used

to prevent possible contamination of the culture medium from a superior aspect. A hole in the cap allowed placement of the culture medium into the well and the taking of samples to check for bacterial contamination. The hole remained sealed at all other times by a cotton plug (fig 3).

Initial testing of model systems for leakage.

All the model systems were sterilized in an ethylene oxide sterilizer and were allowed to set for a minimum of 24 hours for degassing. Using aseptic techniques, each model system was placed in a 4 oz. medicament jar containing 30 ml of sterile trypticase soy broth. The model systems rested on two sterile cotton 2 x 2 inch gauze pads. Following the placement of 5 milliliters of sterile TSB into the wells of the model systems and a 0.1 ml of Proteus vulgaris inoculum into the external TSB, the jar lids were screwed on and the medicament jars and contents were then incubated for 48 hours at 37° C. At the end of 48 hours, blood agar plates were streaked with culture samples from the wells of each model system. This was done to insure that all model systems were initially leak proof prior to the cutting of an occlusal access into the molar crowns.

Access preparation and temporary material placement.

After the model systems had been tested for bacterial leakage, they were all re-sterilized with ethylene oxide. An occlusal access was made in each crown and a notch or recess placed to show at what level the temporary material should be placed to give approximately a 3 mm thickness of IRM[®] or Cavit.*

Utilizing an aseptic technique, IRM was mixed according to

manufacturer's instructions, condensed into the occlusal preparation of 22 models and allowed to set in contact with 20 microliters of 35% CMCP⁺ on a #0 cotton pellet (Fig 4). The model systems were placed in the medicament jars containing sterile TSB and placed in the incubator for 24 hours at 37⁰ C. Similarly, 22 model systems containing Cavit in the access preparations were treated in the same manner. Twenty-one control models each of IRM and Cavit were prepared in the same manner but allowed to set in contact with 20 microliters of sterile saline.

After 24 hours, the cotton pellets containing CMCP or saline were removed and 5 ml of sterile TSB were placed into the model wells. The plastic caps were snapped on and the model systems placed back into the medicament jars. Cotton plugs were placed to seal the openings in the caps, and a culture was taken of the external TSB to verify initial sterility. At this time, a 0.1 ml of Proteus vulgaris inoculum was placed into the external TSB (Fig 5). The medicament jars were returned to the incubator at 37⁰ C.

Culture samples were taken from the TSB in the model wells at 2 days, 1 week, 2 weeks, and 3 weeks after placement of the temporary material to detect bacterial leakage. The culture samples were streaked on blood agar plates, and positive growths were identified using gram staining and the Minitex urease test to confirm the presence of Proteus vulgaris. External TSB was replenished at the 1-week and 2-week periods and samples taken to confirm the vitality of the Proteus vulgaris. At the conclusion of the testing period, the thickness of each temporary restoration was measured with a modified Boley gauge (Fig 6).

RESULTS

One model of the Cavit and saline group was accidentally contaminated and had to be eliminated from the study. Table I gives the number of models leaking at each time period. After 48 hours, 3 models each of IRM setting next to CMCP and saline allowed passage of Proteus vulgaris; whereas, 9 models of Cavit and saline and 11 models of Cavit and CMCP allowed leakage. With time, more and more models demonstrated contamination. After 2 weeks, 100% of the Cavit and saline models had leaked.

Using Fisher's exact probability test, IRM which had set next to CMCP provided a significantly better seal ($p < 0.03$) after 3 weeks than IRM which had set next to saline or Cavit that had set next to CMCP. An even greater degree of significance ($p < 0.01$) may be seen in Cavit setting next to CMCP as compared to Cavit setting next to saline at 2 weeks. The highest degree of significance ($p < 0.0001$) was seen between IRM setting next to CMCP and Cavit next to saline at 2 weeks.

Table II gives the mean thickness of temporary restorative material for each group. No statistical significance could be shown between thicknesses of the temporaries and their leakage pattern.

All blood agar plates that demonstrated positive growth were contaminated by Proteus vulgaris.

DISCUSSION

If microorganisms can gain access to the pulp chamber of teeth undergoing root canal therapy, it may jeopardize the favorable outcome of the treatment. Temporary sealing materials which prevent the ingress of saliva and microorganisms should therefore be used. Various means such

as dyes, radioisotopes, and microorganisms have been used to test the penetrability of numerous materials. Microorganisms are of chief concern; and this study was designed to compare the sealing ability of IRM and Cavit, two frequently used temporary sealing materials. Proteus vulgaris was chosen not because it is found in the oral cavity, but because it is one of the most penetrating and motile organisms available.¹³

The results of this study indicate that both IRM and Cavit do not provide a leak proof seal as assessed by bacterial penetration. Leakage of bacteria is felt by the authors to be more pertinent than leakage of radioisotopes and dyes which may relate more to percolation of small molecules and capillary action.

After 3 weeks, the majority of models in each group had been penetrated by the microorganism; however, the IRM which had set in contact with CMCP provided a significantly better seal. The IRM which had set next to saline did not provide any better seal than Cavit which had set next to CMCP except at the 2-day level.

Both temporaries setting next to CMCP decreased leakage to a significant degree when compared to the same temporary setting next to saline. This relationship was significant at the $p < 0.01$ level at 2 weeks for Cavit and at the $p < 0.03$ level at 3 weeks for IRM. Since Cavit is not softened by CMCP but IRM is,⁹ it appears that the softening of the material during set is not the responsible factor. More likely what causes the decreased leakage is the residual medication which penetrates the temporary during set.

In comparison of materials, IRM made a better seal than Cavit after

setting next to the same solutions. The only exception was a 1 week when the materials had set next to saline.

This study supports the findings of Keller and others¹⁰ which indicated that Cavit sealed no better than IRM and that CMCP did not decrease the seal of IRM.

The results of this study would seem to indicate that the time interval between interim treatment visits should be minimized as much as possible to preclude possible bacterial contamination of the root canal via a leaky temporary restoration. Although the factor of occlusal forces was not accounted for in this study, one would expect the loss of seal by the temporary material in a clinical situation to be even more frequent.

Given IRM's greater strength properties, IRM would be preferable to Cavit as a temporary sealing material when occlusal forces could possibly break the seal. In order to maintain a more predictable seal, it is recommended that CMCP be used next to IRM temporaries. While it is probable that other medicaments which cause a surface softening of the IRM may also increase the sealing potential, this aspect was not studied. It is a clinical impression that the minor surface softening does not reduce strength of the IRM to any significant degree.

SUMMARY AND CONCLUSIONS

Penetration of microorganisms along the IRM or Cavit interface with enamel or dentin was studied using Proteus vulgaris as the test organism.

After 2 weeks, 100% of the models sealed with Cavit that had set next to saline allowed passage of the microorganism. At 3 weeks, 68.2%

of the models sealed with IRM that had set next to CMCP demonstrated leakage; whereas, 95.2% of the models sealed with IRM that had set next to saline and 95.5% of the models sealed with Cavit which had set next to CMCP had leaked. The seal provided by IRM which had set next to CMCP was significantly ($p < 0.03$) better at the 3-week period as compared to IRM and saline, and Cavit and CMCP. The seal of the IRM setting next to saline and Cavit setting next to CMCP were significantly better than Cavit next to saline at the 2-week level ($p < 0.03$, $p < 0.01$).

As evaluated in this study, IRM and Cavit do not provide leak proof seals to the penetration of the microorganism, Proteus vulgaris.

† The Tester Corp., Rockford, IL

L.D. Caulk Co., Milford, DE

* Premier Dental Products Co., Philadelphia, PA

+ Union Broach Co., Long Island City, NY

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Table I. Number and percentage of models leaking at each time period

| | | Total Cases | 2 days | 1 week | 2 weeks | 3 weeks |
|----------------|-----|----------------|--------|--------|---------|---------|
| IRM + CMCP | No. | 22 | 3 | 5 | 10 | 15 |
| | % | 100 | 13.6 | 22.7 | 45.5 | 68.2 |
| IRM + Saline | No. | 21 | 3 | 11 | 16 | 20 |
| | % | 100 | 14.3 | 52.4 | 76.2 | 95.2 |
| Cavit + Saline | No. | 20 | 9 | 10 | 20 | - |
| | % | 100 | 45 | 50 | 100 | - |
| Cavit + CMCP | No. | 22 | 11 | 12 | 15 | 21 |
| | % | 100 | 50 | 54.5 | 68.2 | 95.5 |

TABLE II: Number and average thickness of temporary restorative material for
each group

| | IRM + CMCP | IRM + Saline | Cavit + Saline | Cavit + CMCP |
|---------------------------|------------|--------------|----------------|--------------|
| Number | 22 | 21 | 20 | 22 |
| Average Thickness (mm) | 2.9 | 2.9 | 2.7 | 2.7 |

LEGEND

- Fig 1 Crown setting in acrylic poured into plastic sleeve sitting on glass cone.
- Fig 2 Model system viewed into well created by removal of the glass cone.
- Fig 3 The cap covering the model system with cotton in its opening.
- Fig 4 Model system (MS) during 24 hours following placement of temporary material (TM) into access opening of tooth (T) which is encased in acrylic (A). The temporary material is setting next to a cotton pellet (CP) containing either CMCP or saline. The model system is resting on cotton gauze (CG) which is surrounded by tryptic soy broth (TSB) and sitting in a 4 oz. medicament jar (MJ).
- Fig 5 Model system (MS) with temporary material (TM) in access opening of tooth (T) which is encased in acrylic (A). Tryptic soy broth (TSB) is placed in the well and a cap is snapped over the model and the opening sealed with cotton (C). The model system rests on cotton gauze (CG) surrounded by tryptic soy broth containing Proteus vulgaris (TSB & PV) and sits in a 4 oz. medicament jar (MJ).
- Fig 6 Modified Boley gauge.



FIGURE 1



FIGURE 2

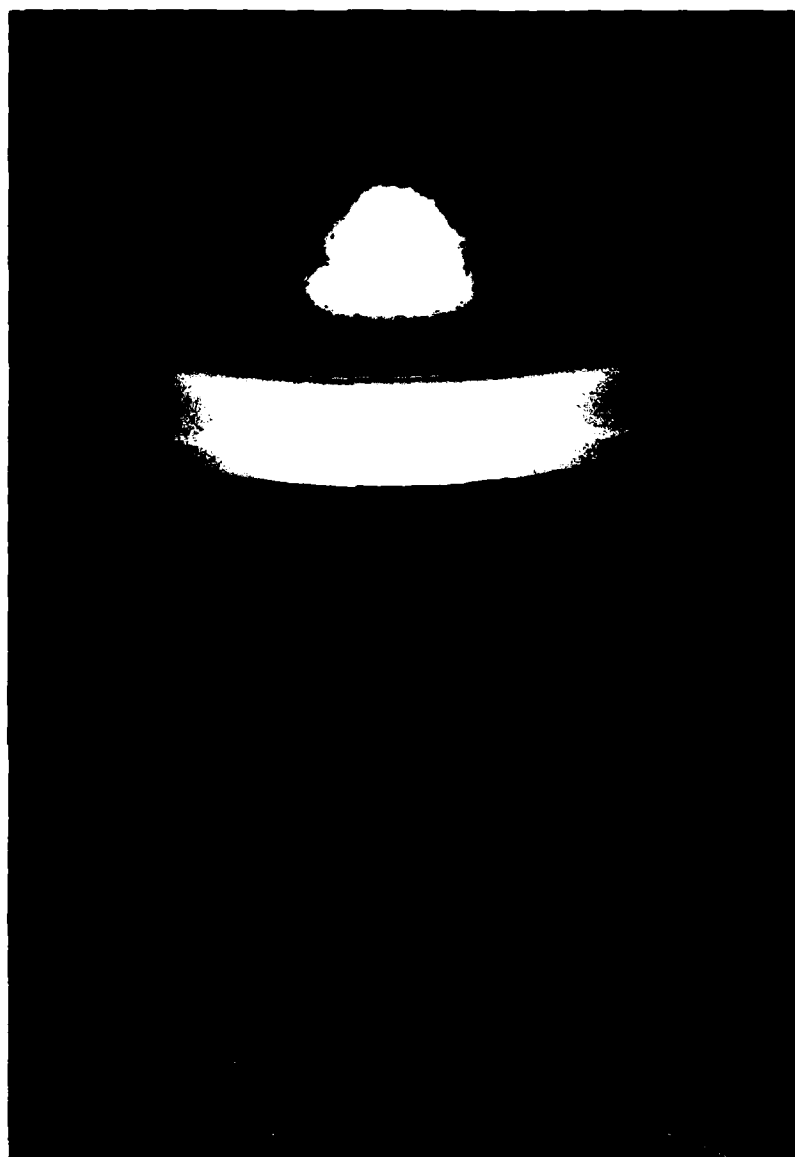


FIGURE 3

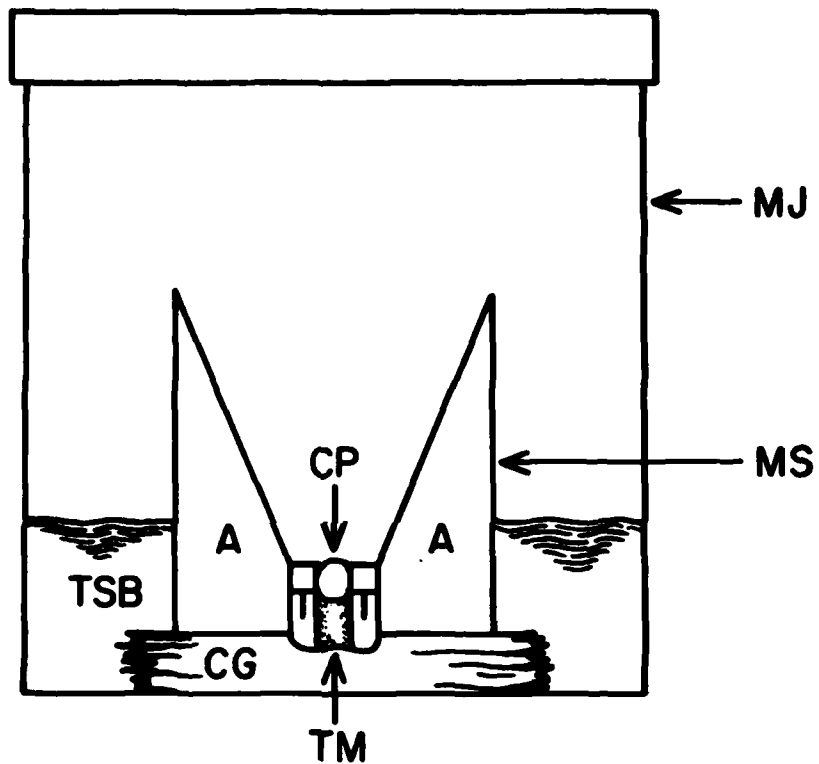


FIGURE 4

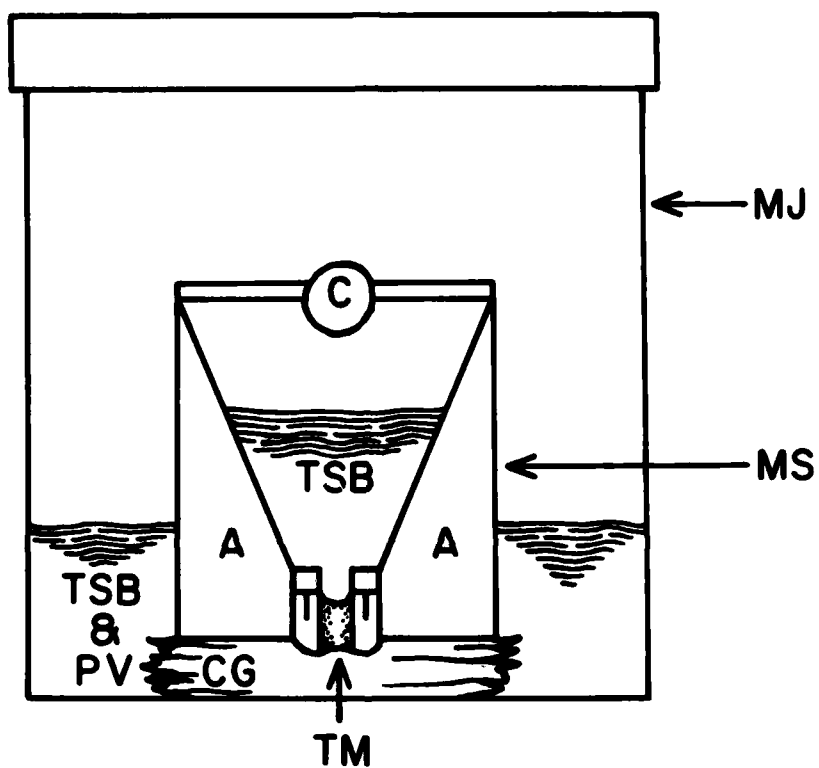


FIGURE 5

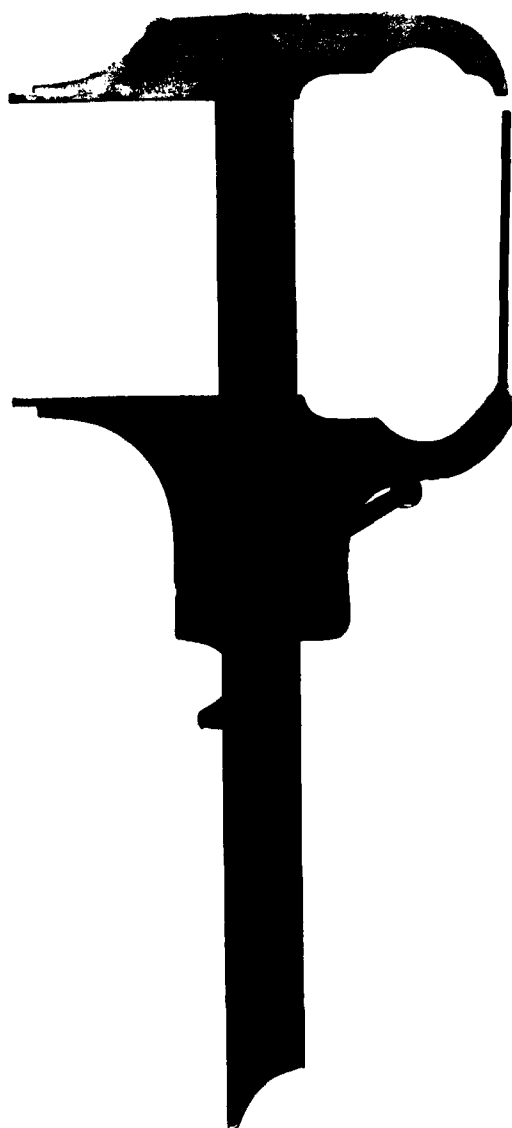


FIGURE 6

